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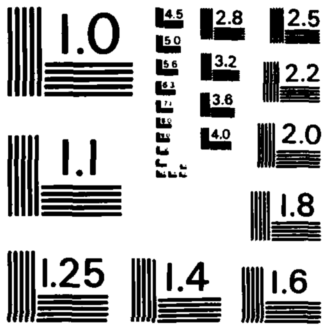
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The Seventh National Quantum Electronics Conference met from 16 through 20 September 1985 in Great Malvern, UK. This report highlights presentations on lasers, nonlinear optics, and quantum optics.

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CONTENTS

QUANTUM ELECTRONICS IN THE UNITED KINGDOM: A NATIONAL-SURVEY CONFERENCE

1 INTRODUCTION

The Quantum Electronics group of the Institute of Physics (UK) has established a fine tradition: every second year a National Quantum Electronics Conference is held in a peaceful location associated with one of the active academic or governmental research centers in this field of research. Quantum electronics, apart from its exciting contributions to our basic understanding of the fundamental processes on the borderline of classical and quantum physics, plays also an ever-increasing role in defense, industry, and consumer services. It is, therefore, fortunate that a rather informal, open, unhurried conference framework exists where senior scientists mix with a strong group of younger researchers (mainly from universities, but also from government research centers and private industry), and with a surprisingly large number of graduate students.

The Seventh National Quantum Electronics Conference met from 16 through 20 September 1985 at Great Malvern. It was hosted by the Royal Signals and Radar Establishment (RSRE), which has its laboratories in this area. Apart from the Institute of Physics, the Royal Society of Chemistry and the Institution of Electrical Engineers (UK) provided support for the meeting. There were about 200 participants, almost exclusively from the UK and the Republic of Ireland. There were 11 invited talks and 50 contributed papers, all delivered without haste (but limited to 30 and 15 minutes, respectively) in unsplit plenary sessions. Half of one day was reserved to the viewing of 38 poster papers. There was sufficient time for both formal and informal discussions.

The talks were grouped into the following categories:

- Lasers (four sessions)
- Nonlinear Optics (two sessions)
- Quantum Optics (two sessions)
- Electro-optics Devices
- Spectroscopy
- Miscellaneous Applications (two sessions)

In this report I will only describe some selected papers in the first, second, and third groups. The choice is primarily personal, but it partly also reflects on the perceived quality. The appendix gives a complete listing of all oral presentations, with names and affiliations of the authors. On request, I shall be glad to supply individual copies of the abstracts that were printed in the *Technical Digest*. I can also send a copy of the list and focal interests of the 30 or so British exhibitors who maintained informative booths at the meeting.

2 SELECTED REVIEWS

<u>Lasers</u>

I think that the talks in this group were the highlights of the conference.

Techniques for generating ultrashort optical pulses have, apparently, continued to advance at a rapid rate. C.V. Shank (a visitor form AT&T Bell Laboratories, New Jersey) gave an informative introduction to this area, describing the generation of pulses as short as 8 femtoseconds, using passive mode locking and pulse compression. Another line of development, described in this talk, was the construction of a high repetition rate (10 kHz) amplifier that can maintain an energy in excess of 1 μJ with a 40-ps pulse width. In the same area, A.S.L. Gomes (Imperial College) talked about work in the optics section concerned with subpicosecond compression of laser pulses. They used a two-stage optical fiber/grating pair arrangement to compress by a factor of 113 the 85-ps pulses from a continuous-wave mode locked Nd:Yag laser. The compression technique has been used also for the Q-switched and mode-locked system, achieving in this experiment higher peak pulse powers.

New solid state lasers were covered by two talks. In the first, M.J.P. Payne discussed work done with H.W. Evans at the RSRE on flashlamp pumped chromium doped gadolinium/scandium/gallium garnet lasers which, as is now generally acknowledged, offer broadly tunable and potentially efficient high-power laser action. The researchers studied the factors that limit performance. They concluded that excited state absorption, color center formation, and thermal lensing in the lasing medium are the major problems. Incidentally, they found that the low slope efficiency (0.02 percent), which was due primarily to high insertion loss and small lasing volume, could be increased to over 0.2 percent if one of the plane mirrors was replaced by a concave one.

A second interesting talk on novel solid state lasers, reporting on a cooperation between Payne and two colleagues at the University of Sheffield, addressed the problem of tunable laser glasses. Probably it will turn out that working with glass is easier than with crystals. But to produce a high yield, broad-band fluorescent glass implies finding suitable dopants (such as 3d or filled-shell ions) and a chemically durable glass with low refractive index and expansion coefficient. The authors studied the effects of glass composition, minor additives, co-doping, furnace temperature, and annealing conditions. The main glass systems chosen were soda lime silicates and variations, a fluoride glass, and a calcium borophosphate glass. The main dopants were Cr^{3+}, Mn^{2+}, Cu^{+}, with reference to Sn^{2+}, Pb^{2+}, Ti^{3+}. One conclusion of the study was that future improvement in fluorescence yield and decay profile may come from suppressing the dipole-dipole interaction.

Single-mode neodymium fiber lasers are also attractive, innovative, solid state devices, and research in this direction was reported by an eight-person cooperative from two departments at the University of Southampton. Such fiber lasers--if end-pumped by, say, a diode laser and if provided with feedback mirrors--allow for attaining a very low oscillation threshold and a very compact, simple, cheap packaging. Weaker transitions may also be capable of laser action, including transitions in dopants which have not previously shown laser action in a glass host. Other possible applications include the use of fibers as amplifiers, reducing in such devices problems of thermal distortion and fracture. The Southampton scientists fabricated the fibers by a modified chemical vapor deposition technique. They used fused silica, with a core diameter of 4 μm and Nd ion concentrations around 300 ppm. In the experiments, end-pumping with a Rhodamine 6G dye laser (and later a GaAs laser) was used. At the lasing wavelength of 1.088 μm, losses were less than 10 dB/km. Resonators have been constructed either with mirrors separated from the fiber ends with microscope objectives, or with mirrors butted against the fiber ends. With the former arrangement, a lasing threshold corresponding to a few milliwatts of absorbed dye laser power was obtained. Continuous-wave, single-mode operation could easily be achieved. Current work focuses on broad tunability, mode locking, and the use of other dopants that may lead to 5 μm or longer wavelength radiation.

There is some interest these days in multi-wavelength operation of lasers. A good presentation in this area was given by R.C. Hollins and D.L. Jordan (RSRE) who described their work on simultaneous lasing of two or more ultraviolet rare gas halide transitions. They studied lasers with XeCl + XeF and with KrF + XeF mixtures. Efficient simultaneous lasing was demonstrated, and it was shown that the compatibility of the different laser media depends critically upon chemical stability of the gas mixture. Excitation transfer processes do not inhibit simultaneous laser action.

In the line of new results with classical designs I wish to report on two developments. R. Wyatt and colleagues at the British Telecom Research Labs described progress with grating-tuned external cavity semiconductor lasers. Their single-transverse-mode InGaAsP chip had one face (the output face) uncoated; the other facet was equipped with an antireflection coating, and it illuminated a collimating lens. The overall cavity was formed between the diffraction grating (1200 lines/mm) and the laser output facet. Tunability over 100 nm around 1.5 μm was easily obtained, with a 10-mW collimated output. The device, now available in a packaged version, has very good spectral performance and should be useful for coherent optical fiber communication detection, sensors, and general spectroscopic and nonlinear optics applications.

The second paper on improvements with standard systems that attracted much attention was presented by I.D. Carr and described the work of a Physics Department group at the University of Southampton on injection seeding of a Nd:Yag laser to give a high-quality, single-longitudinal-mode operation. A single frequency "mini-Yag" master oscillator was pumped by a 20-mW GaAs laser, and, through a Faraday isolator, its output was fed into a Q-switched slave laser (a telescopic Nd:Yag rod laser, giving 100-mJ output in a 30-ns pulse). The slave oscillator had a tuning control (so far manual, but eventually to be replaced by an automatic piezoelectric mirror feedback control circuitry). Of course, the injected dominant mode forces a nearby single mode to be excited very rapidly, thus winning out over competition with other modes (which would be also excited if noise drove the oscillator). The observed single-mode output burst had excellent quality characteristics. Current work aims at stabilization and optimization, so that single longitudinal mode operation can be maintained indefinitely.

Raman lasers and related topics seem to have made a comeback. First of all, I. Duncan read a paper from Queen's University, Belfast, which discussed some novel techniques suitable for the production of tunable, high-power ultraviolet (and possibly vacuum ultraviolet) lasers with a narrow bandwidth. The authors pointed out that stimulated collisional induced fluorescence can compete with stimulated Raman scattering. Under suitable conditions, the collisionally pumped resonance level may be inverted with respect to the lower level of the Raman laser, and a stimulated collisional induced laser is produced. In the second half of the talk, a somewhat related discussion of weakly bound exciplex lasers was given. Probably these may be pumped by flashlight or other incoherent sources. Some experiments are in progress.

High-power Raman amplifiers were the topic of a sophisticated review lecture by M. Shaw (Rutherford-Appleton Laboratory). The highlight of his report on new research was a discussion of his work on three-wave mixing in molecular hydrogen where a pump input from the huge KrF laser is combined in a light-guiding Raman cell with the Stokes output, to give the highly amplified output (at the difference-frequency, of course). He also made the point that in his view, KrF excimer lasers will turn out to be the "ultimate" means for fusion experiments, since by pulse compression and Raman amplification in conjunction with optical multiplexing, ideal tailoring for efficient operation and target isolation can be achieved.

The third paper related to Raman systems was given by D.J. Biswas and R.G. Harrison (Heriot-Watt University, Edinburgh), who reported the first experimental verification of instabilities leading to chaos in a single-mode homogeneously broadened Raman laser system. The route to chaos is characterized by period doubling. The steadiness of the pulsations during uniform pumping suggest single mode instabilities at relatively low excitation above the threshold. The laser used in the experiments had NH_3 as its active medium, was pumped near-resonantly on the aR(6,0) transition by a CO_2 laser, and emitted on an aP(8,0) transition at 12.8 μm. The talk was delivered with the usual enthusiasm of the Heriot-Watt Physics Department group; but I fear that the speaker's final statement--to the effect that discovery of chaotic states in nonlinear dynamics is as epoch making as was the discovery of quantum mechanics 70 years ago--must have turned off several people in the audience.

Nonlinear Optics

I believe there were two coherent sets of talks on topics in nonlinear optics that deserve reporting: (1) optical bistability, and (2) nonlinear phase conjugation.

The first group of talks ties in nicely with the last paper I described in the previous section. Three big groups from Heriot-Watt University reported on topics such as transverse switching waves and cross-talk of bistable elements, two-photon induced quasi-continuous-wave optical bistability in InSb at room temperature, and thermally induced optical bistability in ZnSe thin film interference filters.

To start with, the researchers pointed out that the attainment of projected 10^{10}-10^{12} b/s processing rates for parallel, all-optical switching arrays will depend strongly on the space-bandwidth (spatial resolution) of the array. Thus, transverse coupling between switching elements must be minimized. The so-called "switching wave" phenomenon has been anlayzed and the researchers found that, in case of a nonlinear Fabry-Perot etalon, the behavior of switching waves is critical to the response time, output intensity profile, the degree of hysteresis, and the cross-talk between adjacent devices.

Other members of the group reported on experimental progress. Apparently, quasi-continuous wave optical bistability in the infrared has been observed in InSb at room temperature. It occurred around the two cavity resonances which were obtained by nonlinear tuning of the etalon through two spectral ranges. A second team achieved optical bistability in the visible (500 to 700 nm) range in thin film interference structures made from ZnSe. They think that a band gap resonant process, presently interpreted as a thermal shift of the band edge, resulting in a sensitive change of the index of refraction, is the responsible mechanism. Input power below 10 mW (and corresponding intensity of about 100 W/cm^2) was needed to achieve bistable operation, with switching times as low as a few milliseconds.

Apart from the Heriot-Watt scientists, another research cooperation (between the RSRE and the Redhill Laboratories of Philips Research) also had interesting news to report. These colleagues investigated optical bistability in GaAs/AlGaAs multiple quantum well structures. Both dispersive and absorptive bistability has been observed. The former was achieved with 5-mW input power on the long wavelength side of a Fabry-Perot resonance peak at 844 nm, which is consistent with the increase of the refractive index with temperature (as opposed to the electronic contribution to the nonlinear refraction). Absorptive bistability, in turn, was observed at wavelengths greater than 852 nm (of course, no Fabry-Perot cavity was needed in these experiments). The switching upon increase of the input power is from high to low transmission--i.e., one now has a clockwise hysteresis loop.

As I indicated above, a second preferred topic in the area of nonlinear optics was phase conjugation and degenerate four-wave mixing. I want to describe briefly three interesting papers.

The first two came from Trinity College, Ireland, with W. Blau, C. Maloney, W.M. Dennis, and D.J. Bradley as authors. The researchers reminded the audience that optical phase conjugation in the near infrared should be given more attention than is customary, since optical fiber communication in the 1.3- to 1.5-μm range offers important applications. They also pointed out that the use of organic dye solutions for picosecond degenerate four-wave mixing is a neglected topic, and it was precisely this field that the researchers explored. The best success was achieved with a recently synthesized compound, designated S501*, which has an absorption maximum between 1.1 and 1.6 μm. The experiments (performed with 100-ps pulses of a Nd:Yag laser) utilized a retroreflection geometry. With all three incident light pulses polarized in the same direction, large signals could be observed. Phase conjugate reflectivities of 100 percent were obtained with an input pump pulse intensity of 0.78 GW/cm^2 at a sample transmission of 0.5. The authors concluded that the mixing process arises from thermally induced refractive index changes in the solvent.

In a related second paper, the Trinity College physicists addressed the issue of searching for efficient nonlinear media for phase conjugation that are cheap and easy to manufacture. They suggested that conjugated organic polymers seem very promising, since they have a large delocalized π-electron system which gives rise to high nonlinear polarizabilities. In their experiments they studied in detail optical phase conjugation in solutions of polydiacetylenes in toluene and in chloronaphthalene. These solutions have an absorption maximum near 480 nm. One major conclusion of the experiments was that the dominating process is a thermally induced refractive index change in the solvent. Furthermore, they believe that the response of the temporal coherence of a particular component of the nonlinear susceptibility tensor is the consequence of a Kerr-like nonlinear interaction process.

Since phase conjugation using the photorefractive effect has become an area of great interest, I will conclude this section with a brief report on the University of Essex and Rutherford Appleton Laboratory cooperation (R.W. Eason, A.C. Smout, M.C. Gower) that was the subject of a post-deadline paper. These authors observed a novel self-pulsing behavior in the well-known photoferroelectric material, barium titanate. They noted that the intensity of the reflected phase conjugate beam varies between the "on" and "off" states in a regular fashion, without any apparent external influence. The self-pulsation has a period which depends on the incident laser power. The exact character of the pulses is determined by the crystal orientation. The amplitude of the pulsations may alternate between two distinct values. The transition to the "off" state is always accompanied by a very small frequency shift of the phase conjugate beam.

<u>Quantum Optics</u>

The majority of presentations in this area focused around optical effects which are not describable in terms of fluctuating classical fields, but require the formalism of the quantum theory of radiation. A splendid introduction to this field was given by L. Mandel (University of Rochester, New York). He pointed out that most nonclassical phenomena can be described as falling in one or another (or several) of the following categories:

1. Photon antibunching (fewer photons arrive close together than further apart).
2. Sub-Poissonian photon statistics (the fluctuations of the photon number are smaller than for a Poisson distribution).
3. Correlated two-photon states (photons appear in pairs rather than singly).
4. Squeezed states (one canonical [quatrature] component of the electromagnetic field fluctuates less than it would in the vacuum state).

In the rest of this session, I found the talk by J.G. Walker and E. Jakeman (RSRE) particularly stimulating and simple. These authors suggested that light with sub-Poissonian and antibunched photon statistics could be conveniently generated by using a technique in which a photoelectron-triggered optical shutter is used in conjunction with parametric down-conversion. They proceeded to describe a possible experimental arrangement. Coherent ultraviolet laser light passes through a shutter and impinges on a nonlinear uniaxial crystal (say, ADP). When the correct phase matching conditions are satisfied, the incident photons "split" into pairs of lower frequency. Consider, then, two detectors placed at opposite ends of a diameter of the annular projection of the hollow cone on the detection plane. Each of these detectors will register a Poisson photon-arrival-rate distribution. Since, however, the photons are emitted in pairs, cross correlation of the output from the two detectors will show that the photon arrivals are coincident. Now use the output pulses from one of the detectors as a trigger signal to operate the shutter, which is so constructed that it remains closed for some preset time interval, after which it opens. This process introduces not only "dead times" following counts in the trigger channel but also into the replica photon train incident on the second (monitor) detector. The counts in the trigger channel are obviously sub-Poissonian and antibunched. Yet the optical field between the shutter and the detector is not free for use. This can be seen by inserting a beam splitter into this channel to divert a portion of the light for analysis: one will find an optical field with *bunched* photon statistics. The reason is that the diverted photons are not involved in the triggering process, and the shutter acts only as a chopper as far as the photon beam is concerned. On the other hand, the replica beam *is* free for use, and its properties can be monitored by the second detector. The talk ended with a brief report on the actual preliminary experimental observation of antibunched light.

A second, elegant and erudite talk in this session, by R. Loudon and M. Ley (Essex University), outlined the fundamental properties of optical amplifiers in terms of the relation between their gain and the minimum amount of noise that quantum mechanics requires the device to add to the amplified signal. The inserting of such amplifiers into interferometers produces effects that can be easily analyzed by standard elementary quantum theory techniques. This was done for both the Hanbury-Brown and Twiss experiment and also for the Michelson interferometer. The scientists showed that any improvement in interferometer performance produced by amplification of one of the components in the measured superposition is more than compensated by the effects of amplifier noise. Thus, contrary to suggestions by skeptics regarding the standard interpretation of quantum interference, the insertion of an amplifier will only degrade to some extent the ability of an interferometer to provide "new" information on the fundamental nature of light.

Two additional papers (Imperial College and University of Essex) provided further studies on squeezed optical states; but I will only report on one additional, remotely related paper, presented in the second oral session on quantum optics. This was given by N.G. Walker and J.E. Carroll (Cambridge University). The work was concerned with the quantum theory of multiport optical homodyning. At microwave frequencies the multiport technique for measuring phase and amplitude of a signal is now well established and used in communication systems. The authors entertained the hope that multiport techniques may be also applied in optical communication--for example, to build a receiver for a multilevel phase shift keying system, or for constructing a phase insensitive detector for use in an amplitude shift keying system. The authors developed a rigorous quantum theoretical treatment of multiport homodyne detection, and applied it to a dual balanced receiver configuration which measures the complex amplitude of one of the inputs to a 4×4 directional coupler. By exciting one of the unused input ports into a squeezed ground state, they then derived the homodyne equivalent of the squeezed two-photon coherent state heterodyne measurements which were described in the literature a few years ago. Finally, the Cambridge scientists discussed measurements where only one input port, other than the local oscillator, is excited.

3 CONCLUDING REMARKS

Even though no breakthroughs were reported, nor were unexpected or controversial results communicated at this conference, I feel that it was a good meeting and served a very good cause. The regular, tradition-based, organized yet very free interaction of senior, mid-career, and very young (pre-PhD) scientists and experimental engineers is a great and laudable enterprise. I was told that this year's conference showed a novel feature: there was a greater proportion of workers from industry and applied government labs (relative to academics) than in the previous years. Concomitant to this was an increased proportion of less fundamental and more device-application-type contributions. Perhaps this may give cause for concern, but a good balance will be surely maintained by future organizing committees. The next conference in now already being prepared: it will take place in 1987 at St. Andrews in Scotland.

APPENDIX: CONFERENCE PAPERS

1. Lasers

Recent Advances in Spectroscopy with Femtosecond Optical Pulses, C.V. Shank, AT&T Bell Labs, US.

Sub Picosecond Compression Optimisation and Application of Optically Compressed Nd:YAG Laser Pulses, A.S.L. Gomes, W. Sibbett, and J.R. Taylor, Imperial College, London.

High Repetition Rate Operation of Copper and Gold Vapour Laser, A.J. Kearsley*, A.J. Andrews+, R.R. Lewis+, and C.E. Webb+, *Oxford Lasers, +Clarendon Laboratory.

Flashlamp-Pumped Lasing of Chromium: GSG Garnet, M.J.P. Payne and H.W. Evans, RSRE Malvern.

Demonstration of Self-Pulsing Instabilities in a Single Mode Homogeneously Broadened Raman Laser, R.G. Harrison and D.J. Biswas, Heriot-Watt University, Edinburgh.

Passive Mode Locking of a cw Dye Laser in the Red/Near Infra-red Spectral Region, K. Smith, N. Langford, W. Sibbett, and J.R. Taylor, Imperial College, London.

Laser-induced Autoionisation in Xenon, M.H.R. Hutchinson and K.M.M. Ness, Imperial College, London.

A Dual Wavelength Synchronously Mode-Locked cw Dye Laser, T.F. Lillico, I.S. Ruddock, and R. Illingworth, University of Stratclyde.

Raman and Collisional Induced Lasers, D.G. Cunningham, H. Cormican, I. Duncan, and T. Morrow, Queen's University, Belfast.

A Flashlamp-pumped Dye Laser in a Telescopic Resonator Configuration, P.A. Routledge, A.J. Berry, and T.A. King, Manchester University.

Multi-Wavelength Operation of Rare-Gas-Halide Lasers, R.C. Hollins and D.L. Jordon, RSRE, Malvern.

Tunable Semiconductor Lasers with Narrow Spectral Linewidth at 1.5 μm, R. Wyatt, K. Cameron, and J. Devlin, British Telecom Research Laboratories.

Injection Seeding of a Nd:YAG Laser to give Single Mode Longitudinal Operation, I.D. Carr, A.I. Ferguson, and D.C. Hanna, University of Southampton.

Spectral Characteristics of Free-Running and Injection-Locked HgBr Lasers, H.J. Baker, A.M. Feltham, and N. Seddon, University of Hull.

Single Mode Neodymium Fibre Lasers, R. Mears, D.N. Payne, S. Poole, L. Reekie, I.P. Alcock, A.I. Ferguson, D.C. Hanna, and A.C. Tropper, University of Southampton.

High Efficiency Operation of RF Excited CO_2 Lasers, P. Vidaud, D. He, J.G. Xin, P.J. Wilson, and D.R. Hall, Hull University.

Theoretical and Experimental Studies of Synchronously Pumped Dye Lasers, J.M. Catherall, K. Smith, and G.H.C. New, Imperial College.

High Power Raman Amplifiers, M. Shaw, Rutherford Laboratories.

A High Power Synchronously Pumped Dye Laser System, D.C. Hanna*, D.J. Pointer*, and K.A. Ure+, *University of Southampton, +J.K. Lasers.

Towards a Tunable Laser Glass, D.B. Hollis*, S. Parke*, and M.J.P. Payne+, *University of Sheffield, +RSRE Malvern.

2. Nonlinear Optics

Transverse Switching Waves and Crosstalk of Bistable Elements, I. Galbraith, W.J. Firth, D.J. Hagan, H.A. MacKenzie, J.J.E. Reid, A.C. Walker, J. Young, and S.D. Smith, Heriot-Watt University, Edinburgh.

Two Photon-Induced Quasi-cw Optical Bistability in InSb at Room Temperatures, A.K. Kar, Wei Ji, U. Keller, J.G.H. Mathew, and A.C. Walker, Heriot-Watt University, Edinburgh.

Thermally Induced Optical Bistability in ZnSe Thin Film Interference Filters, M.R. Taghizadeh, J.G.H. Mathew, I. Janossy, and S.D. Smith, Heriot-Watt University, Edinburgh.

Absorptive Optical Bistability in GaAs/AlGaAs Multiple Quantum Wells, A. Miller*, G. Steward*, P. Blood+, K. Woodbridge+, *RSRE, Malvern, +Philips Research Laboratories, Redhill.

Room Temperature Band Gap Resonant Optical Nonlinearities in CdHgTe, D. Craig, A. Miller, and M.R. Dyball, RSRE, Malvern.

Nonlinear Guided-Wave Optics, A.D. Boardman*, P. Egan*, and G.I. Stegemen+, *University of Salford, +University of Arizona.

Compensation of Thermally-Induced Birefringence in a Nd:YAG Amplifier Rod Using SBS Phase-Conjugation, I.D. Carr and D.C. Hanna, University of Southampton.

Picosecond Nonlinear Optical Phase Conjugation in the Near Infra-red, C. Maloney and W. Blau, Trinity College, Ireland.

Experimental Study of the Dependence of the Phase Conjugation Properties of Stimulated Brillouin Scattering (SBS) as a Function of Laser Coherence Length, G.M. Davis* and M.C. Gower+, *Clarendon Laboratories, +Rutherford Appleton Laboratories.

Measurements of the Nonlinear Susceptibility of Liquid Crystal Materials in the Isotropic Phase, A.M. Scott*, F.C. Saunders*, and P.A. Madden, *RSRE Malvern, +University of Oxford.

Acoustic Decay Time Measurements of SBS Hypersound in Heavy Gases at Elevated Pressures, M.J. Damzen, M.H.R. Hutchinson and W.A. Schroeder, Imperial College, London.

Degenerate Four-Wave Mixing of Picosecond Light Pulses in Soluble Polydiacetylenes, W.M. Dennis, W. Blau, and D.J. Bradley, Trinty College, Ireland.

3. Quantum Optics

Squeezed States and Non-Classical Statistics, L. Mandel, Rochester University.

The Description of Two-Mode Squeezed States of Light, S.M. Barnett and P.L. Knight, Imperial College, London.

Output Squeezing for Quantum Optical Systems: Quadrature Phase Spectra, M.J. Collett, University of Essex.

Theory of Interferometers with Optical Amplification, M. Ley and R. Loudon, Essex University.

Generation of Antibunched Light Using a Triggered Optical Shutter in Parametric Down Conversion, J.G. Walker and E. Jakeman, RSRE, Malvern.

Nonclassical Effects in Light Emitted by Three-Level Atoms, A. Al-Hilfy and R. Loudon, Essex University.

Einstein's Rates and Rabi's Flops: A Quantum Optician's View of Resonance, P.L. Knight, Imperial College, London.

Detailed Analysis of Active Mode-Locking Dynamics, L.A. Zenteno, H. Avramopoulos, and G.H.C. New, Imperial College, London.

Exact Analysis of the Effects of Black-Body Radiation and of Finite Cavity Q on the Fluorescence and Absorption from one or more Rydberg Atoms in a Cavity, G.S Agarwal, R.K. Bullough, and G.P. Hildred, UMIST.

Interaction of Three-Level Atoms with Modulated Lasers, D.T. Pegg, Griffiths University, Australia.

Critical Behaviour and Quantum Optical Bistability of the Tavis-Cummings Model in a Driven Low-Q Cavity, R.K.

Bullough, S.S. Hassan, G.P. Hildred, and R.R. Puri, UMIST.

Quantum Theory of Multiport Optical Homodyning, N.G. Walker and J.E. Carroll, Cambridge University.

4. Electro-optics Devices

The Detection of Infra-red Radiation, C.T. Elliott, RSRE.

All-Optical Digital Circuits and Their Application to Optical Computing, A.C. Walker, J.G.H. Mathew, M.R. Taghizadeh, F.A.P. Tooley, B.S. Wherrett, S.D. Smith, and B.S Wherret, Heriot Watt University, Edinburgh.

Excite-Probe and Three Pulse Studies of GaInAsP, R.J. Manning+, A. Miller+, and A.M. Fox*, +RSRE Malvern, *University of Oxford.

5. Spectroscopy

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Fringe Visibility in Optical Ramsey Spectroscopy, B.J. Dalton*, T.D. Kieu*, and P.L. Knight+, *University of Queensland, Australia, +Imperial College, London.

6. Miscellaneous Applications

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